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A NOVEL TECHNIQUE FOR ENHANCING OVERALL NETWORK EFFICIENCY USING COGNITIVE RADIO

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ABSTRACT

Cognitive radio has been considered as a key technology for future wireless communications and mobile computing. Power heterogeneity is also common in CR networks. The benefits of high-power nodes are the expansion of network coverage and also have advantages in power and data transmission rate. So, researchers have made efforts to examine these advantages, like backbone construction i.e., virtual backbone is constructed in a distributed and localized fashion while considering many incompatible objectives like fast convergence, and low computation cost. Topology control helps in conserving the energy by either reducing transmission power per node or preserving energy-efficient routes for the entire network. But, the large transmission range of high power nodes leads to large interference, which reduces the spatial utilization of network channel resources. Because of different transmission power, unidirectional links will occur in the network. Due to these issues, the primary user (PU) of the cognitive radio network will go into shutdown condition. To address this issue and to explore the advantages of high-power nodes, we develop an virtual clustering algorithm to construct a hierarchical network and to eliminate unidirectional links. To reduce the interference raised by high-power nodes, we develop routing algorithms to avoid packet forwarding via high-power nodes. The throughput of power heterogeneous cognitive can be severely impacted by high-power nodes.

Index Terms—Cognitive Radio, Virtual Clustering, Primary User, Hierarchical Nodes, Throughput.

I. INTRODUCTION

In before days, SPECTRUM SHARING TECHNIQUE is used to handle spectrum for cellular wireless wide area, Where two operators own certain parts of the spectrum which is again subdivided into three smaller frequency bands each assigned to one radio access technology (RAT). In those technique spectrum usage is largely licensed access, while only a small part of the spectrum uses license exempt equipment. With licensed access, operators acquire spectrum with sole governance over bands and deploy communication networks to carry a range of services with predictable quality of service (QOS). The amount of licensed spectrum that could be made available for communications in the future is limited by the unavailability of unallocated spectrum, especially below 2 GHz. In the license exempt bands, such as the 2.4 GHz band industrial, Scientific and medical(ISM) band[3], the users need to fulfil a set of criteria to facilitate coexistence of different systems on the same band which in practice means limited transmission power levels and hence reduced coverage. Thus, the ability of license-exempt bands to satisfy the growing data rate demand in the future is limited to short range deployments without predictable Qos[6] due to interference from other uncoordinated users. Hence even unused licensed spectrum exist still a part of users are attaining the scarcity of spectrum. Cognitive radio (CR) is a term for radios that are aware of their surroundings and adapt their transmission parameters (including, but not limited to, carrier frequency and bandwidth) to the environment and the interference situation. The concept of Cognitive radio was first proposed by Joseph Mitola III in a seminar at KTH in 1998 and published in an article by Mitola and Gerald Maguire, Jr.in1999. The key technology enabler for cognitive wireless networks is the "software defined radio (SDR)" which first started to emerge in the 1990's and is now at the pre-commercial stage, perhaps 2-3 years away from consumer deployments. Cognitive radios are expected to communicate across two or three frequency decades by continually sensing the spectrum and identifying available channels. Depending on Transmission and reception parameters, there are two main types of Cognitive radio:

(i) Full Cognitive Radio (Mitola radio), in which every possible parameter observable by a wireless node is considered

(ii) Spectrum-Sensing Cognitive radio, in which only the radio-frequency spectrum is considered. Other types are dependent on parts of the spectrum available for Cognitive radio:

1. Licensed-Band Cognitive Radio 2. Unlicensed-Band Cognitive Radio. A key motivation for the use of CR comes from the fact that spectrum is not exploited to its full extent at all times. If, for example, no active users are present in a cell of a cellular system, the spectrum is unused in this particular area. In order to use the unused spectrum by the secondary users, CR is raised Where the licensed users are primary user and unlicensed users are secondary users. In Cognitive radio, primary users are the users who have higher priority on the usage of specific part of spectrum. Whereas secondary users are the one who have lower priority, exploit the spectrum in such a way that it do not cause any interference to the primary users. Cognitive radio is an adaptive, intelligent radio and network technology that can automatically detect available channels in a wireless spectrum and change transmission parameters enabling more communica-

tions to run concurrently and also improve radio operating behavior. A CR "monitors its own performance continuously", in addition to" reading the radio's output"; it then uses this information to "determine the RF environment, channel conditions, link performance, etc." and adjusts the "radio's settings to deliver the required quality of service subject to an appropriate combination of user requirements, operational limitations and regulatory constraints". This process is a form of dynamic spectrum management. Radio spectrum deployment is growing considerably With respect on finding unutilized frequency channels for new applications has become more challenging. The problem can be solved by letting unlicensed spectrum to dynamically use unexploited licensed bands. This kind of flexible spectrum usage requires telecommunication systems to be equipped by an ability to specify unoccupied parts of radio spectrum. Hence, one main aspect of Cognitive radio is related to autonomously exploiting locally unused spectrum to provide new path to spectrum access. In real-time, there are two primary objectives in mind: (i) highly reliable communications whenever and wherever needed; (ii) efficient utilization of the radio spectrum. Cognitive radios are expected to work in bands below about 3.5 GHz and may be used for a variety of applications, e.g., broadband fixed wireless access, mobile and nomadic access, etc. Cognitive radio system designers must have access to a wide range of channel models covering a wide span of operating frequencies, carrier bandwidths, deployment conditions, and environments. Spectrum sharing is the important component for the establishment of Cognitive radio. when cognitive radio is considered, it is a more general term that involves obtaining the spectrum usage characteristics across multiple dimensions such as time, space, frequency and code. A cognitive radio intelligently utilizes any available side information about the (a) activity, (b) channel condi-tions, (c) encoding strategies or (d) transmitted data sequences of primary users with which it shares the spectrum. Based on the type of available network side information along with the regulatory constraints, secondary users seek to underlay, overlay, or inter-weave their signals. There are three main cognitive radio network paradigms: underlay, overlay, and interweave. In cognitive radio networks the primary users can be cellular or ad hoc, whereas the secondary users are generally ad hoc and fall into the paradigms of underlay, interweave or overlay. Hence, these two types of cognitive radio network users form a two-tier wireless network. In particular, the funda-mental capacity limits of ad hoc networks not only dictate how much information can be transmitted by secondary users under a given set of network and interference conditions, but also limitations on the information exchange possible between sensing nodes to collaboratively assess spectral occupancy. Cognitive radios offer the promise of being a disruptive technology innovation that will enable the future wireless world. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their transmission waveform, channel access method, spectrum use, and networking protocols as needed for good network and application performance. Until recently, technology was the primary impediment to achieving universal, broadband wireless services that involve multiple radio access technologies. The proliferation of wireless broadband usage over the last decade has led to the development and deployment of multiple broadband wireless radio access technologies (RATs) such as Wi-Fi, WiMAX, HSPA and LTE. To support the ever-increasing wireless traffic demand, researchers have worked on the concept of an integrated heterogeneous wireless environment that encompasses several of these RATs which makes the resource allocation process more efficient by assigning each user in the system to the best RAT/RATs. The demand for spectrum is at an all time high due to the increasing popularity of wireless devices. As such it is imperative that technological and regulatory mechanisms are developed to maximize spectral efficiency.

II. Cognitive Cycle

A. Spectrum sensing

A CR monitors the available spectrum bands, captures their information and detects the spectrum holes Detect unused spectrum and share spectrum without interference with other user.

B. Spectrum management

CR captures the best available spectrum to meet user communication requirements.

C. Spectrum mobility

Maintains seamless communication requirements during transition to better spectrum.

D. Spectrum sharing

Provides fair spectrum scheduling method among coexisting CR users.

E. Power Control

It is usually used for Spectrum sharing CR systems to maximize the capacity of secondary users with interference power constraints to protect the primary users.

F. Spectrum analysis

The characteristics of spectrum holes that are detected through spectrum sensing are estimated.

G. Spectrum decision

A CR determines the data rate, the transmission mode and bandwidth of the transmission. Then, the appropriate spectrum band is chosen according to spectrum characteristics and user requirements.

Once the spectrum band is determined, the communication can be performed over this spectrum band. However, since the radio environment changes over time and space, the CR should keep track of the changes of the radio environment. If the spectrum band in use becomes unavailable, the spectrum *mobility* function is performed to provide a seamless transmission. Any environmental change during the transmission such as primary user appearance, user movement, or traffic variation can trigger this adjustment.

In order to implement loose virtual clustering, the Spectrum sharing function is considered. Almost all the function of Cognitive Radio was interdependent on each and hence used at different parts of the network.

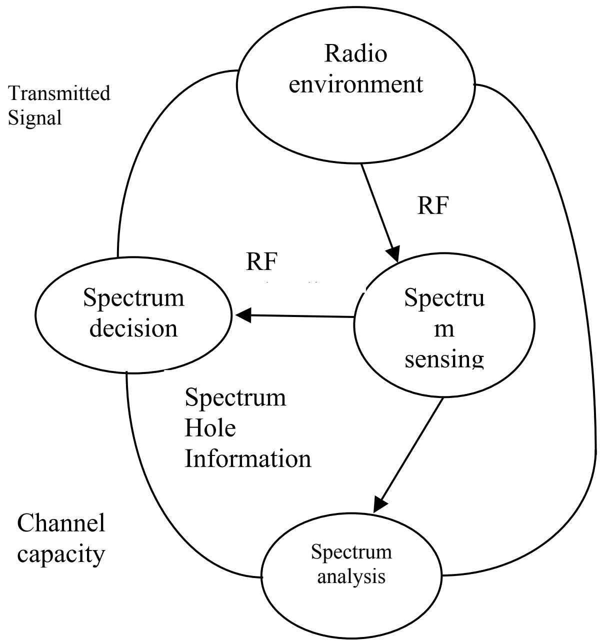

Fig.1 Cognitive Cycle

III. Spectral-Energy efficiency

The basic existing system for Cognitive radio consists of two techniques, namely: (i)Switching- In which always Switch Over condition occurs (ii) Non Switching-In this condition, Always Wait condition occurs (i.e.) SU will always stay on a PU(current channel)till the end of busy condition, even when other PU are free. The initial analysis has studied the spectral-energy efficiency trade-off for a link-level CR network under transmit power and interference constraints .The drawbacks are:

- It only concentrates on high-power link nodes to choose secondary network.
- Naturally high power link node creates large noise and interference in the wireless sensor network.

Before going into the analysis, the system that lies beyond the improvisation of spectral-energy efficiency starts with tremendous efforts and progress in past decades for improving efficiency in wireless network. In general, spectral efficiency is the amount of information that can be transmitted per unit frequency band in a wireless network. Whereas, more and more energy is consumed in wireless network to guarantee QOS.

In **wireless network**, improving the energy efficiency will not only reduce their impact on environment but also cut network costs and make communication more affordable for everyone. Spectral efficiency (SE) and Energy efficiency (EE) are the 2 different metrics for measuring the wireless network efficiency. Some design criteria optimized for improving one metric may not necessarily improve the other. The SE-EE relationship varies depending on the type of wireless networks. Physical-MAC layer is designed to improve wireless SE-EE because the 2 layers closely depend on each other. Therefore, SE is crucial for all wireless networks because it allows the network to maximize utilization of associated frequency. One main goal is to increase SE as much as possible. Also it is crucial to improve EE of wireless from both infrastructure and device perspective. Hence, the energy efficient communication has been paid increased attention under the background of limited energy resource and environment friendly transmission behaviors. Reducing energy consumption in wireless communication has attracted increasing attention recently by using MIMO and OFDM techniques.

For the **MIMO system** [7], only large antennas can improve SE and EE. Typically, increasing SE is associated with increasing power and hence with decreasing EE. Therefore there lies a fundamental trade-off between the EE and SE. However, in one operating regime it is possible to jointly increase the EE and SE and in this regime, there is no trade-off [8]. Certain activities like multiplexing to many users rather than beam-forming to a single user and increasing the number of service antennas can simultaneously benefit both the SE and radiated EE. The SE is in the order of 10-30 bits/HZ. The relative EE is obtained by normalizing the energy efficiency and therefore dimensionless. At low SE, the EE increases when the SE increases.

In case of **cellular network**, a distributed approach is used to improve SE. SE is the widely accepted metric which can be defined by the system throughput for unit bandwidth. In contrast, EE has previous been ignored by most research efforts and has not considered as an important performance indicator until very recently.

Unfortunately, SE and EE are not always consistent and sometimes conflict with each other therefore how to balance the 2 metrics needs careful study. Hence, A trade-off is analyzed. Existing research results show that routing protocols over unidirectional links perform poorly in multihop wireless networks. In LVC, unidirectional links in the network can be discovered using a BN discovery scheme.

To exploit the benefit of high power nodes establishes a hierarchical structure for the network. However, the existing routing protocols in power heterogeneous are only designed to detect the unidirectional links and to avoid the transmissions based on asymmetric links without considering the benefit of high power nodes. Hence the problem is to improve the routing performance of power heterogeneous by efficiently exploiting the advantages and avoiding the disadvantages of high power nodes.

The Massive MIMO [8] (multiple-input, multiple-output) concept was proposed in the seminal paper as an attractive way to improve the spectral efficiencies of future networks by orders of magnitude. The last ten years have seen a massive growth in the number of connected wireless devices. Billions of devices are connected and managed by wireless networks. At the same time, each device needs a high throughput to support applications such as voice, real-time video, movies, and games. Demands for wireless throughput and the number of wireless devices will always increase. In addition, there is a growing concern about energy consumption of wireless communication systems. Thus, future wireless systems have to satisfy three main requirements: i) having a high throughput; ii) simultaneously serving many users; and iii) having less energy consumption. Massive multiple-input multiple-output (MIMO) technology, where a base station (BS) equipped with very large number of antennas (collocated or distributed) serves many users in the same time-frequency resource, can meet the above requirements, and hence, it is a promising candidate technology for next generations of wireless systems.

Cognitive Radio along with Massive MIMO will provide enhanced performance when compared to the current generation networks.

IV. PROPOSED SYSTEM

A. Loose Virtual Clustering

To overcome the problem of improving the throughput and power heterogeneity and reducing interference, a loose-virtual-clustering-based (LVC) routing protocol for power heterogeneous (LRPH) is proposed .The algorithm aim at creating bi directional links by exploiting the advantages of high-power nodes. In order to decrease the interference raised by high-power nodes, routing algorithms are developed to avoid packet forwarding via high-power nodes.

- We consider two types of nodes in the networks: B-nodes with high power nodes and a large transmission range. G nodes - low power with small transmission range. The number of B-nodes (Backbone nodes) and G-nodes (General nodes) are denoted as NB and NG, respectively and there transmission ranges as RB and RG, respectively. The state of G-nodes in the network is defined as G isolated - G-node that is not covered by any B-node. G member - G-node whose bidirectional neighbors (BNs) are covered by its cluster head. G gateway - G-node whose BNs are not covered by its cluster head.
- Two features appear in LVC. First, the loose clustering avoids heavy overhead caused by reconstructing and maintaining the cluster when the density of B-nodes is small. Second, LRPH protocol can be adaptive to the density of B-nodes, even when all G-nodes are in the Gisolated state. All nodes build a PWR table by exchanging control packets during building LVC. The basic step is building a PWR.

Algorithm:

- **Step 1**: G-nodes send G-node initialization packets(GI) to all B-nodes in its AN table. The packet will have the information on its Bidirectional links.
- **Step 2**: Each B-node once receiving the GI packets will add the BN to LAT. The B-node then sends B node initialization (BI) packets to all G-nodes in its coverage area.
- **Step 3**: Once G-node receives the BI packet, it updates the PWR table.
- **Step 4**: A G-node declares it as a member to cluster head by sending cluster member, register (CMR) packet to cluster head.
- **Step 5**: Cluster head replies with a cluster head declare (CHD) packet and updates it PWR. Cluster head maintains the PWR for each member G-node.

The basic steps of building the PWR table can be further explained with the help of the flowchart. It clearly explains how far the spectrum is utilized by G node.

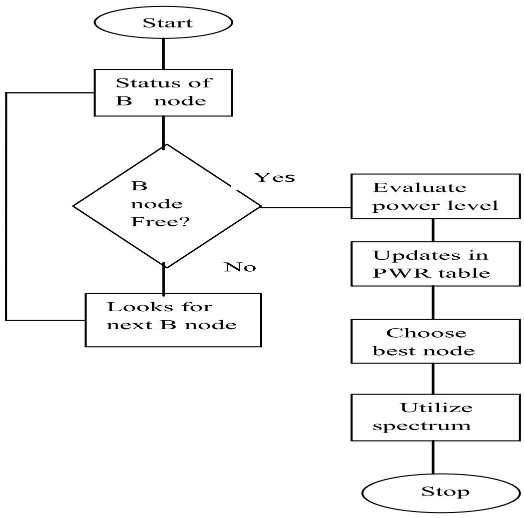

Fig.2. Flowchart of the Proposed Work

C. Route Discovery:

The G-nodes in LRPH take more responsibility for forwarding data packets to the destination. Nevertheless, the energy consumption of G-nodes might not necessarily be faster than that of high-power nodes. In particular, for a network with light traffic load, the energy consumption of the network mainly comes from the control

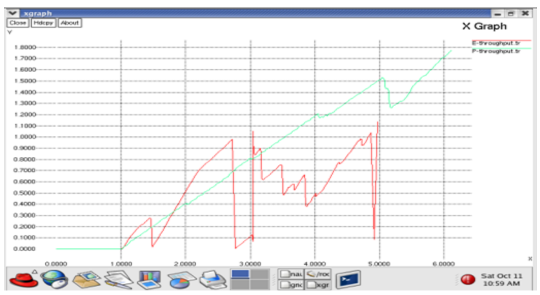

Fig.3 Average Network Throughput Performance

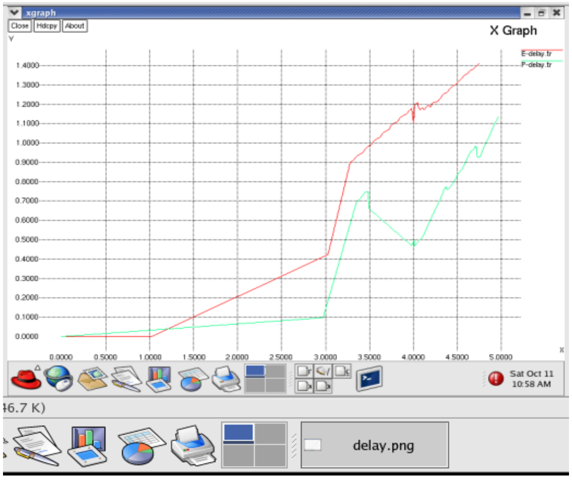

Fig.5 Energy Consumption of the Overall Network

packets for maintaining the network, and B-nodes may consume energy faster than G-nodes.

First, B-nodes in LRPH play the role of cluster head; more control information should be transmitted for the purpose of local network management and maintenance (e.g., CHD packets).

1. Second, the energy consumption of B-nodes for transmitting per bit data is much higher than G-nodes. The routing components in LRPH, including the route discovery and route maintenance. In the route discovery, the route to the destination can be obtained effectively based on LVC. In the route maintenance procedure, we deal with cases such as route failure. To improve the network performance and to address the issues of high power nodes, they propose an LRPH protocol. We highlight some unique features of our route discovery procedures. First, our technique takes the large coverage space for B-nodes to the broadcast RREQ (Route Request) packet. Hence, the delay from the route discovery can be improved. Second, forwarding rules for the RREQ packet is based on the state of a node and local topology information; therefore, redundant transmissions of RREQ packets can be avoided, and the overhead of the route discovery procedure can be significantly reduced.
2. Third, our scheme intends to avoid forwarding data packets through B-nodes; therefore, the impact of B-nodes on network throughput can be largely reduced. Finally, LRPH is adaptive to the density of B-nodes for LVC. In an extreme case where no B-node exists in the network, i.e., the state of all nodes belongs to *G* isolated; LRPH becomes a routing protocol similar to classical source routing. Fortunately, all mechanisms and transmissions in LRPH are based on the bidirectional links. The difference is that LRPH forwards data packets through bidirectional links and improves transmission efficiency.

V. Results and Discussions

Throughput and Delay was considered for the parameter estimation, which is used to define the performance of the proposed system. Energy consumption was also calculated which is considered as the significant parameter, hence it must be reduced to the great extent for the development of next generation systems.

Figure.3 represents the throughput performance of the proposed system which produces the enhanced result when compared to the existing techniques. Almost the throughput gets increased by about 30% - 40% with respect to the extreme value algorithm.

Figure.4 and 5 represents the delay and energy consumption curve. Almost it get reduced about 35% for the former one and it was 48% for the second one.

VI. Conclusion and Future Scope

This paper investigates the importance of spectral and energy efficiency over the Cognitive Radio network. For which power heterogeneity of hierarchical (PU) nodes plays a important role. Hence the problem of power heterogeneity was analyzed and performance was improved using loose virtual clustering with power heterogeneous protocol. Simulation results show that the LVC algorithm works when better compared to the existing techniques. Moreover Cognitive Radio has been a promising technology for the next generation networks. Better spectral and energy efficiency can be by implementing cognitive radio along with Massive MIMO. Hence Massive MIMO can be designed with low power components.

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